

# Implementation of a Parallel 3D Thermal Convection Software Package

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## Abstract

Thermal convective motions driven by horizontal or vertical temperature gradients often play an essential role in the behavior of geophysical and astrophysical systems, and obtaining a detailed understanding of their roll is often at the core of many important problems in the Earth and Planetary sciences.

Applications include the dynamics of atmospheres and oceans, stellar convection, convection in gaseous protostellar disks and in Earth's fluid core. This talk will focus on the implementation of a general parallel version of state-of-the-art software in various computer environments for use by scientists and engineers in the Earth and Space field for solving the thermal convection problem for a wide variety of systems characterized by different geometries and dynamical regimes.

The software is designed to run on massively parallel systems, and uses a state-of-the-art finite volume method coupled with a parallel multigrid linear solver algorithm. The present version of the code has been tested successfully on the Cray T3E, the HP/Convex SPP2000, the Beowulf system and some other distributed-memory systems and shared-memory systems.

Numerical results are obtained for Rayleigh numbers up to  $5 \times 10^7$  and for a Prandtl number 0.733 equivalent to that of air, in a cubical enclosure, which is heated differentially at two vertical sidewalls. Separations of the flow near the horizontal walls occur, and  $y$ -variations of the flow are strong. Periodical flow patterns appear. The 3D solutions for such high Rayleigh number  $5 \times 10^7$  become strong convective, time-dependent, and periodical. Besides the capability of studying side-heating convective problems, the present 3D software is ready to explore Rayleigh-Benard flows, rotation flows. Some numerical results for these studies are also discussed.

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